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But in the footnote at the bottom of page 609, by the term "Lake ore" the writer really means "Lake copper" and his statement that "the term has now lost its original meaning" is hardly justifiable, since in the first place for "ore" one should read "copper," and in the second place, that western copper should have been almost fraudulently sold as Lake copper does not signify that the term has lost its meaning; otherwise there would have been no object in the trick. In fact the difference in selling price between Lake copper and electrolytic copper has been unusually great at times during the last three years.

Although of course, the book is primarily a text-book, yet the summaries of different theories as to ore deposits (see, for instance, the discussion of Mississipi zinc), often largely based upon original studies, are so valuable that no one interested in its field can afford to be without the book.

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SPECIAL ARTICLES

EXPERIMENTS WITH A FOCAULT PENDULUM

In the issue of SCIENCE for March 16, last Dr. Carl Barus, under the above title, described certain measurements of the rotation of the plane of oscillation of a Focault pendulum. The present note gives, for the same determination, another method that is simple, direct and of fair accuracy.

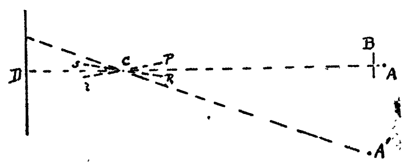

FIG. 1.

If in Fig. 1 the point A represent an arc lamp that, through the slit B, illuminates a portion of the scale D; and if PQ represent the plane of vibration of a Focault pendulum at a given time, it is evident that the diffraction pattern of the wire will travel up and down the scale as the pendulum oscillates. Further, as the plane of the vibration rotates about the center at C, the amplitude of the motion of the shadow on D will decrease, and will become zero at the instant when the oscillation plane includes the line DCA. This amplitude of the shadow's motion will increase again as the plane of vibration continues its rotation towards the position RS. If the position on the scale of one edge of the central band be taken at each successive elongation of the pendulum; and if these readings be plotted against the time (in terms of the period of the pendulum) two approximately

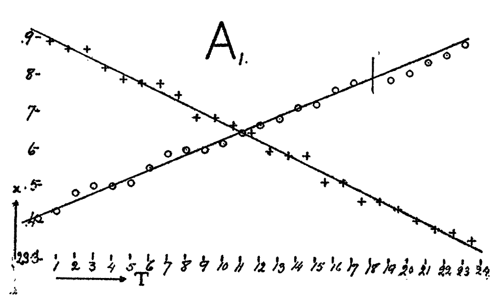

FIG. 2*a*.

straight lines will be obtained. The coordinates of the intersection of these lines will give (1) the point on the scale where it is cut by the vertical plane that includes the line AC; and (2) the time (in terms of the period of the pendulum) of the coincidence of the plane of vibration with the vertical plane defined in (1) (see Fig. 2, *a* and *b*).

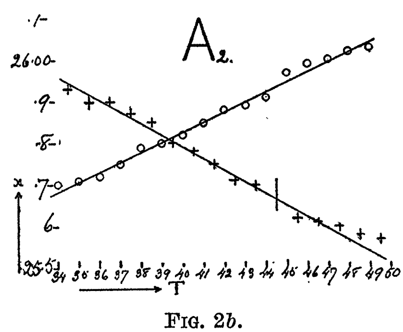

FIG. 2*b*.

If, next, the lamp be moved to a position indicated in Fig. 1 by A' a similar set of observations will determine a second vertical plane and the time of passage of the plane of vibration through it. The number of oscillations that elapse between a given observation of the first set and a given observation of the

second set is determined by starting a stop-watch as the first reading of the first set taken, and stopping it at the first observation of the second set. This time divided by the known period of the pendulum will fix the number of oscillations from the first of one set to the first of the other, *i. e.,* it will give the oscillation number of the first elongation of the second set, the initial elongation of the first set being taken as zero. Thus knowing the distance of the scale D from the center of oscillation C, and the intersections of the two vertical planes at D, we get the angle between them; and from this and the time interval the angular velocity of the rotation of the plane of vibration follows at once.

The first attempts to use this method were made with the slit about two meters from the center at C, and the scale six meters away. The observations were made on the first diffraction minimum to one side of the pattern, but the decay of the amplitude of vibration introduced here an undeterminable correction which was too large to be neglected. The final procedure was to put the arc about six meters from the center and to bring the scale to two meters. Readings were then made of the edge of the central dark shadow—the bright line in the middle of the shadow being too faint for quick reading. Under these circumstances the variation of the width of the central shadow, even in its extreme positions, was negligible.

The Apparatus.—A turned leaden sphere of mass 4.8 kilograms was suspended from a roof joist of the laboratory by a long steel piano wire 0.39 mm. diam. Attached to the wire, so that its shadow would cross the scale D at each oscillation, was a small ball of wax. As the screen was about a meter above the floor and the arc about 20 centimeters, this shadow was at its highest point at one maximum elongation of the bob and at its lowest at the other. By noting the motion of the shadow of the wax ball at the ends of its path one could detect any tendency to elliptical motion of the bob. The prevention of such motion is, of course, one of the difficulties in securing good results.

The period of the pendulum was 7.50 secs.

To start the oscillation the bob was drawn back 40 or 50 cm. from its equilibrium position and held there by a belt of thread that passed about its equator and through a small horizontal pulley, which latter was fastened to a standard by the thread which was to be burned in releasing the pendulum (see Fig. 3). The object of the pulley was to prevent torsional strain in the wire, but as the restoring couple was so small for the wire in question it was found best to place a mark on the sphere after it had been hanging at rest for some time, and to adjust the ball in its belt so that the mark was at its original azimuth. Next, to damp out side motion of the bob the following device proved efficient; a flat disc of cork (about 2 cm. diam.) was fixed centrally on the inside of a light tin dish (top of a coffee can, 11 cm. diam. See Fig. 3) and this was floated on cylinder oil in

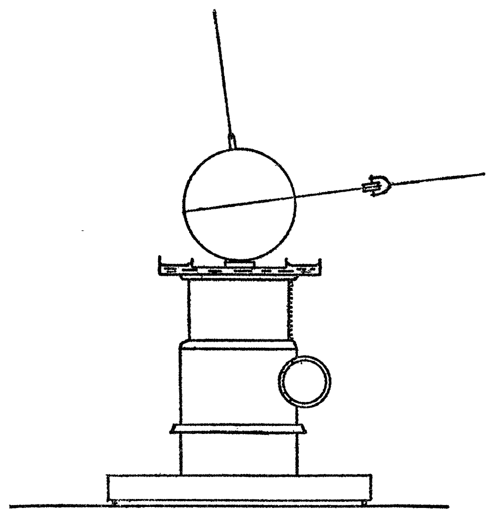

Fig. 3.

a larger vessel that was carried on a table that could be racked up and down (the front of a projection lantern). This system was placed centrally under the bob in its deflected condition, and was raised until the cork just touched the sphere. The slight friction between them caused the dish to move with the bob, so that the oil quickly damped the resid-

ual motion. When all was perfectly still—as indicated by the absence of movement of the shadow D—the damping system was lowered away and the thread behind the pulley quickly burned through. If the bob were left hanging after the removal of the damping system, air currents and the tremors of the building soon set it swinging again—for these observations were made while other operations were being carried on in the same building. After releasing the bob the position of the arc lamp was adjusted so that the amplitude of the shadow's motion was decreasing and was about 5 mm. on the scale. Readings were then made of successive elongations until the plane of the pendulum's motion had passed completely through the plane fixed by the slit and the vertical through the point C. Readings were always begun with the outward swing of the pendulum so that no ambiguity resulted from the recording only the millimeters and tenths after the first. The record for the first few points of experiment A (below) for instance was :

23.42 cm.
.89
.47
.87
etc.

Blanks (when the arc sputtered or the eye did not catch the turning point) were indicated, both in the record and on the graph, by strokes.

The determination of the point on the floor directly beneath the center of suspension was effected as follows: A metal plate with a peephole (1 mm. diam.) was held in the laboratory stand so that the plumb-bob, hung through the hole, fell just over the edge of one of the feet of the stand, about a meter below. A straightedge placed on the floor against this foot, when observed through the peep-hole, defined a vertical plane. The bob was then set swinging through an arc of amplitude equal to its own radius and the position of the straight-edge was adjusted until at extreme elongations the sphere appeared tangent to the straight-edge on opposite sides successively. A line drawn along the straight-edge must contain a point vertically under the center of suspension. In this same manner two other lines, each at about 60° to the first, were determined, and the center of the resulting triangle (about 1 mm. altitude) was taken as the point required.

Trouble was found at first at the suspension point itself, but this was finally overcome by boring a 5-mm. hole half way through a stout piece of brass and finishing it through with a half millimeter drill. The wire was then inserted, the larger hole being in the lower side of the bar. The hole was then filled with solder, sufficient being used to leave the surface slightly convex. This excess was scraped away with a knife, leaving a plane surface from which the pendulum could swing. The bar was then clamped into place against the roof joist.

The details of a set of five consecutive readings taken on the fifteenth of May, 1917, are as follows:

Latitude of Kingston 44° 13′.

Period of Pendulum $T = 7.50$ sec.

Distance to scale from center of oscillation

Coordinates of intersections of lines on graph t_1, t_2, x_1, x_2.

Angular velocity of plane of vibration

$$\omega = \frac{x_2 - x_1}{(t_2 - t_1)T200}$$

Experiment	t_1	t_2	x_1 (cm.)	x_2 (cm.)	ω (Radians per Second)
A	10.9 T	39.3 T	23.65	25.81	5.07×10^{-5}
B	19.5 T	64.5 T	21.58	24.92	4.95
C	10.5 T	44.1 T	20.90	23.39	4.95
D	13.3 T	53.9 T	20.94	24.04	5.09
E	14.4 T	48.6 T	22.64	25.30	5.18
Mean					5.05×10^{-5}
Calculated value at Kingston					5.08×10^{-5}

Of these the experiment of shortest duration was A, which included 28.4 periods or about 3½ minutes; the longest was B, of 45 periods, or about 5½ minutes.

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